Investigation and Development of the Osseous Part of BoneWelding® Hybrid Implants

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INTRODUCTION

To enhance the stability of the bone-implant interface, a new process, the BoneWelding® Technology, has been developed during the recent years by WoodWelding AG, offering new alternatives in the treatment of fractures and other degenerative disorders of the muskuloskeletal system[1,2]. The BoneWelding® process employs ultrasonic energy to liquefy a thermoplastic interface between orthopaedic implants and the host bone. The BoneWelding® process is compatible with many thermoplastics, including current resorbable orthopaedic polymers.

Significant potential is seen in so called hybrid concepts, wherein the polymer is applied on the load bearing implant as a complete coating. This concept allows the combination of the load transfer characteristics of the polymer-bone interface with the high mechanical properties of metallic or ceramic core material.
The aim of this project was to investigate and develop the osseous part of such a novel hybrid implant with titanium core and resorbable polymer coating.

1 S.J. Ferguson, et al (2006) ; J Biomed Mater Res Part B: Appl Biomater 77B: 13-20
2 D.C. Meyer, et al (2005) ; Clin. Ortho. Rel.Res 442m 143.148

MATERIALS & METHODS

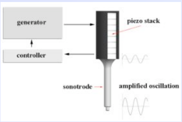

Fig. 1: The principle of ultrasonic devices

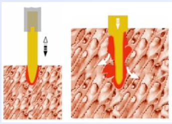

Fig. 2: Implant oscillation and friction causes the polymer coating to melt

Fig. 3: The ultrasonic device Branson LPe (20kHz)

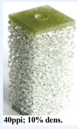

Fig. 4: Duocel AL-foam with E-Glass® cortex

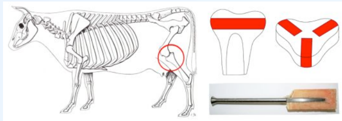

Fig. 5: Bovine proximal tibiae from 4 to 6 year old animals were taken as substitutes for human bone

Fig. 6: Hybrid implant with titanium core and PLDLLA coating (diameter: 5.5mm, length of the implant tip: 40mm)

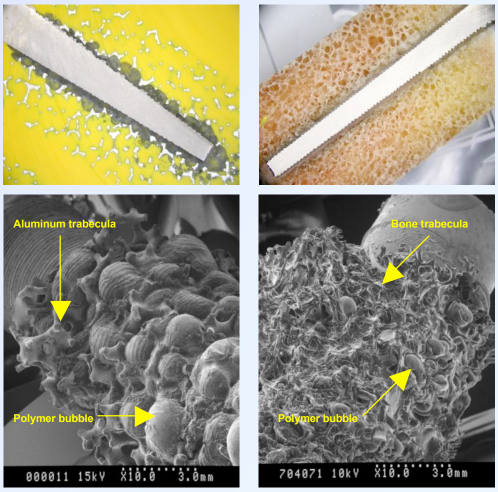

Fig. 7: Hybrid implants inserted into low densitiy aluminium foam as a substitute material for osteoporotic bone (left pictures) and bovine proximal tibia (right pictures). The strong micro infiltration is clearly visible.

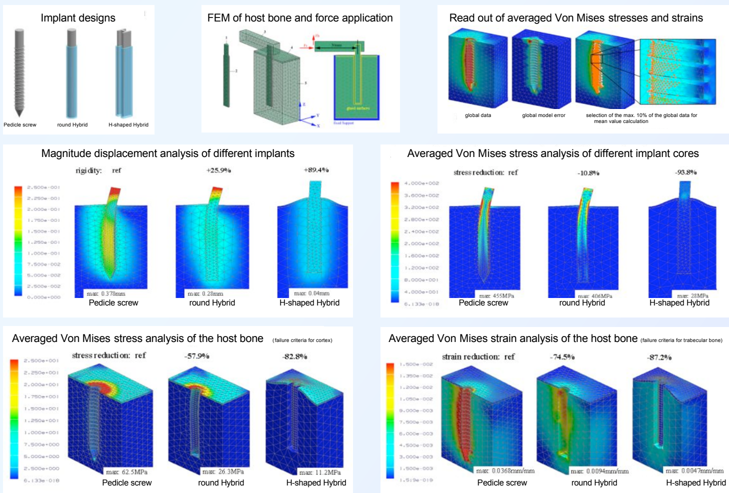

Fig. 8: Different hybrid designs, as well as classic Pedicle screws, were evaluated in a FEM study. It could be shown, that e.g. bending optimized hybrids are likely to reduce induced stresses and strains in the host bone significantly, while enhancing the implants rigidity.

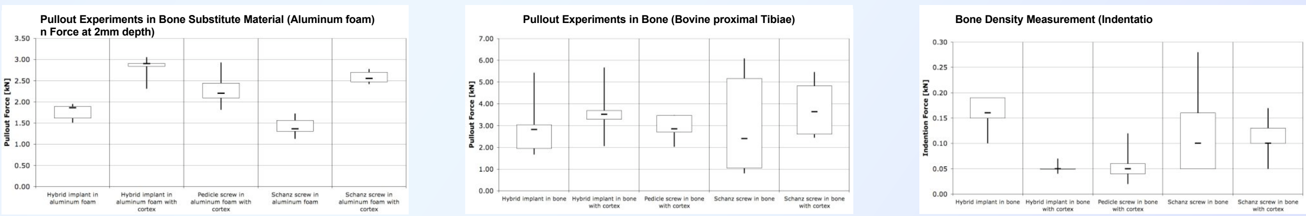

Fig. 9: Round BoneWelding® Hybrids were compared to commercially available Schanz- and Pedicle screws in static pullout experiments. All implants were evaluated in bone substitute material and bovine proximal tibiae. In respect to the density of each bone sample, the Hybrid implant showed a good performance in comparison with Schanz- and Pedicle screws. Pullout forces in the osteoporotic bone model were significantly higher for the hybrids, due to the strong microinfiltration interface between polymer and trabeculae.

RESULTS

It could be shown that a homogenous infiltration of the polymer along the implant can be achieved (see Fig. 7) and that infiltration depth can be controlled by the thickness and volume of the polymer coating. In respect to the density of each bone sample, the hybrid implant showed a good performance in comparison with Schanz- and Pedicle screws (see Fig. 9). In osteoporotic bone model, the hybrid implant showed a significant higher performance due to the strong microinfiltration interphase between the polymer and the trabeculae. This strong micro infiltration was also observed in SEM analysis of the hybrid implants (see Fig. 7). The FEM study showed significant reductions for induced stresses and strains in the host bone along with increased implant rigidity, for bending optimized implants (see Fig. 8).

OUTLOOK

The obtained results show a very promising potential of the developed hybrid implants, especially when applied in osteoporotic bone. FEM optimized implants are likely to reduce induced stresses and strains in the host bone significantly, while enhancing the implants rigidity.

ACKNOWLEDGMENT

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